

What is claimed is:

1. A network connection system for connecting a first communication network and a plurality of user terminals when a second communication  
5 network is interposed between said first communication network and said plurality of user terminals, said second communication network employing a second protocol different from a first protocol employed in said first communication network, said system comprising:
  - a scheduling apparatus including:
    - 10 an overhead amount correction unit for correcting an overhead amount between data conforming to said second protocol and data conforming to said first protocol to convert received information on a rate based on said second protocol to a rate based on said first protocol; and
    - 15 a scheduler for shaping a transmission rate for the data conforming to said first protocol from said first communication network such that the data conforming to said first protocol is delivered at a transmission rate equal to or lower than said rate calculated by said overhead amount correction unit;
    - 20 a protocol converter for converting data conforming to said first protocol after said scheduling apparatus has shaped the transmission rate therefor to data conforming to said second protocol for use in said second network; and
    - a multiplexer including a current data detector for supplying said  
25 scheduling apparatus with said rate information as indicative of a currently set reception rate for said user terminals, said multiplexer being configured

to transmit to each of said user terminals the data conforming to said second protocol from said protocol converter or the data conforming to said first protocol after said scheduling apparatus has shaped the transmission rate therefor.

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2. A network connection system for connecting a first communication network and a plurality of user terminals when a second communication network is interposed between said first communication network and said plurality of user terminals, said second communication network employing a second protocol different from a first protocol employed in said first communication network, said system comprising:

a scheduling apparatus including:

a classification processing unit for classifying data conforming to said first protocol received from said communication network based on quality guaranteed classes set thereto;

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an overhead amount correction unit for correcting an overhead amount between a data rate associated with said first protocol and a data rate associated with said second protocol to convert received rate information on said second protocol to the rate based on said first protocol;

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a weighting coefficient calculation unit for calculating a weighting coefficient based on said rate calculated by said overhead amount correction unit such that a minimally guaranteed rate is assured for a minimum rate guaranteed class among classes classified by said classification processing unit;

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a weighting scheduler for scheduling data conforming to

said first protocol of said minimum rate guaranteed class and of a weighting applied class among said classified classes based on the weighting coefficient calculated by said weighting coefficient calculation unit to deliver the data in accordance with the scheduling; and

a scheduler for scheduling the data conforming to said first protocol from said weighting scheduler such that the data conforming to said first protocol is delivered at a transmission rate equal to or lower than said rate calculated by said overhead amount correction unit to deliver the data in accordance with the scheduling;

a protocol converter for converting the data conforming to said first protocol after said scheduling apparatus has shaped the transmission rate therefor to data conforming to said second protocol; and

a multiplexer including a current data detector for supplying said scheduling apparatus with said rate information as indicative of a currently set reception rate for said user terminals, said multiplexer being configured to transmit to each of said user terminals the data conforming to said second protocol from said protocol converter or the data conforming to said first protocol after said scheduling apparatus has shaped the transmission rate therefor.

3. A network connection system for connecting a first communication network and a plurality of user terminals when a second communication network is interposed between said first communication network and said plurality of user terminals, said second communication network employing a

second protocol different from a first protocol employed in said first communication network, said system comprising:

a scheduling apparatus including:

5 a classification processing unit for classifying data conforming to said first protocol received from said communication network based on quality guaranteed classes set thereto;

10 an overhead amount correction unit for correcting an overhead amount between a data rate associated with said first protocol and a data rate associated with said second protocol to convert received rate information on said second protocol to the rate based on said first protocol;

15 a weighting coefficient calculation unit for calculating a weighting coefficient based on said rate calculated by said overhead amount correction unit such that a minimally guaranteed rate is assured for the minimum rate guaranteed class among classes classified by said classification processing unit;

20 a weighting scheduler for scheduling data conforming to said first protocol of said minimum rate guaranteed class and of a weighting applied class among said classified classes based on the weighting coefficient calculated by said weighting coefficient calculation unit to deliver the data in accordance with the scheduling; and

25 a preferential control scheduler for scheduling the data conforming to said first protocol from said weighting scheduler, and data conforming to said first protocol of a best-effort class among said classified classes such that the data conforming to

said first protocol is delivered at a transmission rate equal to or lower than said rate calculated by said overhead amount correction unit, and for preferentially scheduling the data conforming to said first protocol from said weighting scheduler, and delivering the data conforming to said first protocol of the best-effort class at a timing at which there is no data conforming to said first protocol from said weighting scheduler;

a protocol converter for converting the data conforming to said first protocol after said scheduling apparatus has shaped the transmission rate therefor to data conforming to said second protocol; and

a multiplexer including a current data detector for supplying said scheduling apparatus with said rate information as indicative of a currently set reception rate for said user terminals, said multiplexer being configured to transmit to each of said user terminals the data conforming to said second protocol from said protocol converter or the data conforming to said first protocol after said scheduling apparatus has shaped the transmission rate therefor.

4. A network connection system for connecting a first communication network and a plurality of user terminals when a second communication network is interposed between said first communication network and said plurality of user terminals, said second communication network employing a second protocol different from a first protocol employed in said first communication network, said system comprising:

a scheduling apparatus including:

a classification processing unit for classifying data

conforming to said first protocol received from said communication network based on quality guaranteed classes set thereto;

a rate measuring unit for measuring a transmission rate for a preferential class among said classified classes;

5 an overhead amount correction unit for correcting an overhead amount between a rate based on said second protocol and a rate based on said first protocol to convert received rate information on said second protocol to the rate based on said first protocol;

10 a weighting coefficient calculation unit for calculating a weighting coefficient based on said rate calculated by said overhead amount correction unit and the transmission rate for the preferential class measured by said rate measuring unit such that a minimally guaranteed rate is assured for the minimum rate  
15 guaranteed class among the classes classified by said classification processing unit;

a weighting scheduler for scheduling data conforming to said first protocol of said minimum rate guaranteed class and of a weighting applied class among said classified classes based on  
20 the weighting coefficient calculated by said weighting coefficient calculation unit to deliver the data in accordance with the scheduling; and

a preferential control scheduler for scheduling the data conforming to said first protocol of said preferential class, the data  
25 conforming to said first protocol from said weighting scheduler, and data conforming to said first protocol of a best-effort class

among said classified classes such that the data conforming to said first protocol is delivered at a transmission rate equal to or lower than said rate calculated by said overhead amount correction unit, and for preferentially scheduling the data conforming to said first protocol of said preferential class, preferentially scheduling the data conforming to said first protocol from said weighting scheduler at a timing at which there is no data conforming to said first protocol of said preferential class, and delivering the data conforming to said first protocol of the best-effort class at a timing at which there is no data conforming to said first protocol from said weighting scheduler;

a protocol converter for converting the data conforming to said first protocol after said scheduling apparatus has shaped the transmission rate therefor to data conforming to said second protocol; and a multiplexer including a current data detector for supplying said scheduling apparatus with said rate information as indicative of a currently set reception rate for said user terminals, said multiplexer being configured to transmit to each of said user terminals the data conforming to said second protocol from said protocol converter or the data conforming to said first protocol after said scheduling apparatus has shaped the transmission rate therefor.

5. A network connection system for connecting a first communication network and a plurality of user terminals when a second communication network is interposed between said first communication network and said plurality of user terminals, said second communication network employing a

second protocol different from a first protocol employed in said first communication network, said system comprising:

a scheduling apparatus including:

5 a classification processing unit for classifying data conforming to said first protocol received from said communication network based on quality guaranteed classes set thereto;

a rate measuring unit for measuring a transmission rate for a preferential class among said classified classes;

10 an overhead amount correction unit for correcting an overhead amount between a rate based on said second protocol and a rate based on said first protocol to convert received rate information on said second protocol to the rate based on said first protocol;

15 a preferential class upper limit setting unit, operative when the difference between the transmission rate of the data conforming to said first protocol of the preferential class as measured by said rate measuring unit and said rate calculated by said overhead amount correction unit is lower than a minimally guaranteed rate for a minimum rate guaranteed class among the  
20 classes classified by said classification processing unit, for setting an upper limit to the transmission rate for said preferential class for shaping, such that the minimally guaranteed rate can be assured for said minimum rate guaranteed class;

25 a weighting coefficient calculation unit, operative when said preferential class upper limit setting unit does not set the upper limit, for calculating a weighting coefficient based on said



rate calculated by said overhead amount correction unit and the transmission rate for the preferential class measured by said rate measuring unit such that the minimally guaranteed rate is assured for the minimum rate guaranteed class among the classes  
5 classified by said classification processing unit, said weighting coefficient calculation unit being further operative when said preferential class upper limit setting unit sets the upper limit, for calculating a weighting coefficient based on said rate calculated by said overhead amount correction unit and the upper limit rate  
10 set by said preferential class upper limit setting unit such that the minimally guaranteed rate is assured for said minimum rate guaranteed class;

a weighting scheduler for scheduling data conforming to said first protocol of said minimum rate guaranteed class and of  
15 a weighting applied class among said classified classes based on the weighting coefficient calculated by said weighting coefficient calculation unit to deliver the data in accordance with the scheduling; and

a preferential control scheduler for scheduling the data  
20 conforming to said first protocol of said preferential class, the data conforming to said first protocol from said weighting scheduler, and data conforming to said first protocol of a best-effort class among said classified classes, such that the data conforming to said first protocol is delivered at a transmission rate equal to or  
25 lower than said rate calculated by said overhead amount correction unit, and for preferentially scheduling the data

conforming to said first protocol of said preferential class,  
preferentially scheduling the data conforming to said first protocol  
from said weighting scheduler at a timing at which there is no data  
conforming to said first protocol of said preferential class, and  
5 delivering the data conforming to said first protocol of the best-  
effort class at a timing at which there is no data conforming to said  
first protocol from said weighting scheduler;

a protocol converter for converting the data conforming to said  
first protocol after said scheduling apparatus has shaped the transmission  
10 rate therefor to data conforming to said second protocol; and

a multiplexer including a current data detector for supplying said  
scheduling apparatus with said rate information as indicative of a currently  
set reception rate for said user terminals, said multiplexer being configured  
to perform DSL processing using telephone lines to transmit to each of said  
15 user terminals the data conforming to said second protocol from said  
protocol converter or the data conforming to said first protocol after said  
scheduling apparatus has shaped the transmission rate therefor.

6. A network connection system for connecting a first communication  
20 network and a plurality of user terminals when a second communication  
network is interposed between said first communication network and said  
plurality of user terminals, said second communication network employing a  
second protocol different from a first protocol employed in said first  
communication network, said system comprising:

25 a scheduling apparatus including:

a classification processing unit for classifying data

conforming to said first protocol received from said communication network based on quality guaranteed classes set thereto;

an overhead amount correction unit for correcting an overhead amount between a rate based on said second protocol and a rate based on said first protocol to convert received rate information on said second protocol to the rate based on said first protocol;

a weighting coefficient calculation unit for calculating a weighting coefficient based on said rate calculated by said overhead amount correction unit and the transmission rate for a preferential class among said classified classes using information fed back from said user terminals such that a minimally guaranteed rate is assured for the minimum rate guaranteed class among the classes classified by said classification processing unit;

a weighting scheduler for scheduling data conforming to said first protocol of said minimum rate guaranteed class and of a weighting applied class among said classified classes based on the weighting coefficient calculated by said weighting coefficient calculation unit to deliver the data in accordance with the scheduling; and

a preferential control scheduler for scheduling the data conforming to said first protocol of said preferential class, the data conforming to said first protocol from said weighting scheduler, and data conforming to said first protocol of a best-effort class among said classified classes such that the data conforming to said first protocol is delivered at a transmission rate equal to or

lower than said rate calculated by said overhead amount correction unit, and for preferentially scheduling the data conforming to said first protocol of said preferential class, preferentially scheduling the data conforming to said first protocol from said weighting scheduler at a timing at which there is no data conforming to said first protocol of said preferential class, and delivering the data conforming to said first protocol of the best-effort class at a timing at which there is no data conforming to said first protocol from said weighting scheduler;

10 a protocol converter for converting the data conforming to said first protocol after said scheduling apparatus has shaped the transmission rate therefor to data conforming to said second protocol; and

a multiplexer including a current data detector for supplying said scheduling apparatus with said rate information as indicative of a currently set reception rate for said user terminals, said multiplexer being configured to perform DSL processing using telephone lines to transmit to each of said user terminals the data conforming to said second protocol from said protocol converter or the data conforming to said first protocol after said scheduling apparatus has shaped the transmission rate therefor.

20 7. A network connection system for connecting a first communication network and a plurality of user terminals when a second communication network is interposed between said first communication network and said plurality of user terminals, said second communication network employing a second protocol different from a first protocol employed in said first communication network, said system comprising:

a scheduling apparatus including:

a classification processing unit for classifying data conforming to said first protocol received from said communication network based on quality guaranteed classes set thereto;

5 an overhead amount correction unit for correcting an overhead amount between a rate based on said second protocol and a rate based on said first protocol to convert received rate information on said second protocol to the rate based on said first protocol;

10 a preferential class upper limit setting unit, operative when the difference between the transmission rate for a preferential class among said classified classes determined to be using information fed back from said user terminals and said rate calculated by said overhead amount correction unit is lower than a  
15 minimally guaranteed rate for a minimum rate guaranteed class among the classes classified by said classification processing unit, for setting an upper limit to the transmission rate for said preferential class for shaping such that the minimally guaranteed rate can be assured for said minimum rate guaranteed class;

20 a weighting coefficient calculation unit, operative when said preferential class upper limit setting unit does not set the upper limit, for calculating a weighting coefficient based on said rate calculated by said overhead amount correction unit and the transmission rate for the preferential class such that the minimally  
25 guaranteed rate is assured for said minimum rate guaranteed class, said weighting coefficient calculation unit being further

operative when said preferential class upper limit setting unit sets the upper limit, for calculating a weighting coefficient based on said rate calculated by said overhead amount correction unit and the upper limit rate set by said preferential class upper limit setting unit such that the minimally guaranteed rate is assured for said minimum rate guaranteed class;

a weighting scheduler for scheduling data conforming to said first protocol of said minimum rate guaranteed class and of a weighting applied class among said classified classes based on the weighting coefficient calculated by said weighting coefficient calculation unit to deliver the data in accordance with the scheduling; and

a preferential control scheduler for scheduling the data conforming to said first protocol of said preferential class, the data conforming to said first protocol from said weighting scheduler, and data conforming to said first protocol of a best-effort class among said classified classes such that the data conforming to said first protocol is delivered at a transmission rate equal to or lower than said rate calculated by said overhead amount correction unit, and for preferentially scheduling the data conforming to said first protocol of said preferential class, preferentially scheduling the data conforming to said first protocol from said weighting scheduler at a timing at which there is no data conforming to said first protocol of said preferential class, and delivering the data conforming to said first protocol of the best-effort class at a timing at which there is no data conforming to said

first protocol from said weighting scheduler;

a protocol converter for converting the data conforming to said first protocol after said scheduling apparatus has shaped the transmission rate therefor to data conforming to said second protocol; and

5 a multiplexer including a current data detector for supplying said scheduling apparatus with said rate information as indicative of a currently set reception rate for said user terminals, said multiplexer being configured to perform DSL processing using telephone lines to transmit to each of said user terminals the data conforming to said second protocol from said  
10 protocol converter or the data conforming to said first protocol after said scheduling apparatus has shaped the transmission rate therefor.

8. The network connection system according to claim 1, wherein said current rate detector periodically applies the rate information to said  
15 scheduling apparatus at regular time intervals.

9. The network connection system according to claim 1, wherein said current rate detector applies the rate information to said scheduling apparatus when the set rate based on said second protocol is updated.  
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10. The network connection system according to claim 1, wherein said current rate detector supplies said scheduling apparatus with said rate information as indicative of a transmission rate set between a user terminal and said multiplexer in the event of hand-shaking.  
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11. The network connection system according to claim 1, wherein said

first communication network is an IP network, said data conforming to said first protocol is an IP packet, said second network is an ATM network, and said data conforming to said second protocol is an ATM cell.

- 5 12. A traffic shaping method, in a network connection system for connecting a communication network and a plurality of user terminals, for shaping a transmission rate for data conforming to a first protocol from said communication network, said method comprising the steps of:

10 classifying data conforming to said first protocol received from said communication network based on quality guaranteed classes set thereto;

correcting an overhead amount between a rate based on a second protocol and a rate based on said first protocol to convert received rate information on said second protocol to the rate based on said first  
15 protocol;

calculating a weighting coefficient such that a minimally guaranteed rate is assured for a minimum rate guaranteed class among said classified classes based on said calculated rate;

20 scheduling data conforming to said first protocol of said minimum rate guaranteed class and of a weighting applied class among said classified classes based on the calculated weighting coefficient to deliver the data in accordance with the scheduling; and

scheduling the data conforming to said first protocol after said weighting, and data conforming to said first protocol of a best-effort class  
25 among said classified classes, such that the data conforming to said first protocol is delivered at a transmission rate equal to or lower than said



calculated rate, and for preferentially scheduling the data conforming to said first protocol after said weighting, so that the data conforming to said first protocol of said best effort class is delivered at a timing at which there is no data conforming to said first protocol after said weighting.

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13. A traffic shaping method, in a network connection system for connecting a communication network and a plurality of user terminals, for shaping a transmission rate for data conforming to a first protocol from said communication network, said method comprising the steps of:

10 classifying data conforming to said first protocol received from said communication network based on quality guaranteed classes set thereto;

correcting an overhead amount between a rate based on a second protocol and a rate based on said first protocol to convert received rate information on said second protocol to the rate based on said first protocol;

15 calculating a weighting coefficient such that a minimally guaranteed rate is assured for a minimum rate guaranteed class among said classified classes based on said calculated rate;

20 scheduling data conforming to said first protocol of said minimum rate guaranteed class and of a weighting applied class among said classified classes based on the calculated weighting coefficient to deliver the data in accordance with the scheduling; and

25 scheduling the data conforming to said first protocol after said weighting, such that the data conforming to said first protocol is delivered at a transmission rate equal to or lower than said calculated rate, to deliver the

data in accordance with the scheduling.

14. A traffic shaping method, in a network connection system for connecting a communication network and a plurality of user terminals, for shaping a transmission rate for data conforming to a first protocol from said communication network, said method comprising the steps of:

classifying data conforming to said first protocol received from said communication network based on quality guaranteed classes set thereto;

measuring a transmission rate for a preferential class among said classified classes;

correcting an overhead amount between a rate based on a second protocol and a rate based on said first protocol to convert received rate information on said second protocol to the rate based on said first protocol;

calculating a weighting coefficient based on said calculated rate and the transmission rate measured for the preferential class such that a minimally guaranteed rate is assured for a minimum rate guaranteed class among the classified classes;

scheduling data conforming to said first protocol of said minimum rate guaranteed class and of a weighting applied class among said classified classes based on the calculated weighting coefficient to deliver the data in accordance with the scheduling; and

scheduling the data conforming to said first protocol of said preferential class, the data conforming to said first protocol after said weighting, and data conforming to said first protocol of a best-effort class

among said classified classes such that the data conforming to said first protocol is delivered at a transmission rate equal to or lower than said calculated rate, and for preferentially scheduling the data conforming to said first protocol of said preferential class, preferentially scheduling the data conforming to said first protocol after said weighting at a timing at which there is no data conforming to said first protocol of said preferential class, and delivering the data conforming to said first protocol of the best-effort class at a timing at which there is no data conforming to said first protocol after said weighting.

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15. A traffic shaping method, in a network connection system for connecting a communication network and a plurality of user terminals, for shaping a transmission rate for data conforming to a first protocol from said communication network, said method comprising the steps of:

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classifying data conforming to said first protocol received from said communication network based on quality guaranteed classes set thereto;

measuring a transmission rate for a preferential class among said classified classes;

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correcting an overhead amount between a rate based on said second protocol and a rate based on said first protocol to convert received rate information on said second protocol to the rate based on said first protocol;

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when the difference between said measured transmission rate of the data conforming to said first protocol of the preferential class and said calculated rate is lower than a minimally guaranteed rate for a minimum rate

guaranteed class among said classified classes, setting an upper limit to the transmission rate for said preferential class for shaping such that the minimally guaranteed rate can be assured for said minimum rate guaranteed class;

5                calculating a weighting coefficient based on said calculated rate and said transmission rate measured for the preferential class such that a minimally guaranteed rate is assured for said minimum rate guaranteed class, when the upper limit rate is not set for said preferential class, and calculating a weighting coefficient based on said calculated rate and said set upper limit  
10    rate such that the minimally guaranteed rate is assured for said minimum rate guaranteed class when the upper limit rate is set for said preferential class;

                 scheduling data conforming to said first protocol of said minimum rate guaranteed class and of a weighting applied class among said classified  
15    classes based on said calculated weighting coefficient to deliver the data in accordance with the scheduling; and

                 scheduling the data conforming to said first protocol of said preferential class, the data conforming to said first protocol after said weighting, and data conforming to said first protocol of a best-effort class  
20    among said classified classes such that the data conforming to said first protocol is delivered at a transmission rate equal to or lower than said calculated rate, preferentially scheduling the data conforming to said first protocol of said preferential class, preferentially scheduling the data conforming to said first protocol after said weighting at a timing at which  
25    there is no data conforming to said first protocol of said preferential class, and delivering the data conforming to said first protocol of the best-effort

class at a timing at which there is no data conforming to said first protocol after said weighting.

16. A traffic shaping method, in a network connection system for  
5 connecting a communication network and a plurality of user terminals, for  
shaping a transmission rate for data conforming to a first protocol from said  
communication network, said method comprising the steps of:
- classifying data conforming to said first protocol received from  
said communication network based on quality guaranteed classes set  
10 thereto;
  - correcting an overhead amount between a rate based on a  
second protocol and a rate based on said first protocol to convert received  
rate information on said second protocol to the rate based on said first  
protocol;
  - 15 calculating a weighting coefficient based on said calculated rate  
and the transmission rate for a preferential class among said classified  
classes determined to be using information fed back from said user terminals  
such that a minimally guaranteed rate is assured for a minimum rate  
guaranteed class among said classified classes;
  - 20 scheduling data conforming to said first protocol of said minimum  
rate guaranteed class and of a weighting applied class among said classified  
classes based on said calculated weighting coefficient; and
  - scheduling the data conforming to said first protocol of said  
preferential class, the data conforming to said first protocol after said  
25 weighting, and data conforming to said first protocol of a best-effort class  
among said classified classes such that the data conforming to said first

protocol is delivered at a transmission rate equal to or lower than said calculated rate, preferentially scheduling the data conforming to said first protocol of said preferential class, preferentially scheduling the data conforming to said first protocol after said weighting at a timing at which  
5 there is no data conforming to said first protocol of said preferential class, and delivering the data conforming to said first protocol of the best-effort class at a timing at which there is no data conforming to said first protocol after said weighting.

10 17. A traffic shaping method, in a network connection system for connecting a communication network and a plurality of user terminals, for shaping a transmission rate for data conforming to a first protocol from said communication network, said method comprising the steps of:

classifying data conforming to said first protocol received from  
15 said communication network based on quality guaranteed classes set thereto;

correcting an overhead amount between a rate based on a second protocol and a rate based on said first protocol to convert received rate information on said second protocol to the rate based on said first  
20 protocol;

when the difference between the transmission rate for a preferential class among said classified classes determined using information fed back from said user terminals and said calculated rate is lower than a minimally guaranteed rate for a minimum rate guaranteed class  
25 among said classified classes, setting an upper limit to the transmission rate for said preferential class for shaping such that the minimally guaranteed

rate can be assured for said minimum rate guaranteed class;

calculating a weighting coefficient based on said calculated rate and the transmission rate for the preferential class such that the minimally guaranteed rate is assured for said minimum rate guaranteed class, when  
5 the upper limit rate is not set for said preferential class, and calculating a weighting coefficient based on said calculated rate and said upper limit rate set for said preferential class such that the minimally guaranteed rate is assured for said minimum rate guaranteed class, when the upper limit rate is set for said preferential class;

10 scheduling data conforming to said first protocol of said minimum rate guaranteed class and of a weighting applied class among said classified classes based on said calculated weighting coefficient; and

scheduling the data conforming to said first protocol of said preferential class, the data conforming to said first protocol after said  
15 weighting, and data conforming to said first protocol of a best-effort class among said classified classes such that the data conforming to said first protocol is transmitted at a transmission rate equal to or lower than said calculated rate, preferentially scheduling the data conforming to said first protocol of said preferential class, preferentially scheduling the data  
20 conforming to said first protocol after said weighting at a timing at which there is no data conforming to said first protocol of said preferential class, and delivering the data conforming to said first protocol of the best-effort class at a timing at which there is no data conforming to said first protocol after said weighting.

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18. The traffic shaping method according to claim 12, wherein said

first communication network is an IP network, said data conforming to said first protocol is an IP packet, said second network is an ATM network, and said data conforming to said second protocol is an ATM cell.